Environment Canada

Environnement Canada

Inland Waters Directorate

Ontario Region

Direction générale des eaux intérieures

Region de l'Ontario

Canada

REPORT ON STATUS OF OPEN WATERS OF LAKE ONTARIO - 1984-

M. Neilson and R.J.J. Stevens

After the intensive years, 1981 and 1982, minimal effort was expended on Lake Ontario in 1983 to allow an in-depth surveillance program to be conducted on Lake Superior, as identified in the Great Lakes International Surveillance Plan (GLISP). Only two full chemistry cruises were conducted on Lake Ontario: March 14-18 (8322001) and April 5-8 (8322004). The 94 stations shown in Figure 1 were sampled as outlined in Table 1. Physical parameters, as well as the less stable nutrients filtered nitrate-plus-nitrite, filtered ammonia and soluble reactive phosphorus, were analyzed onboard ship at the time of collection. The remaining parameters were returned to the National Water Quality Laboratory in Burlington for analysis.

Data from these cruises were used to report any incidents of objective noncompliance and to update trend analysis of phosphorus and nitrogen. Surface concentrations, when compared with mean whole water column concentrations in a paired t-test, have been found to be representative of the entire water column (report in progress). Therefore, trend studies from 1970 to 1983 were based solely on spring surface concentrations. Statistical analysis involved the use of both collected surface data and area-weighted means. The latter values were calculated using the computer program ALDAR (Neilson et al. 1984) and the 17 zones illustrated in Figure 2.[1].

Data have been graphically presented using the "box plot" (McGill et al. 1978). The median for each year is represented by a dashed line within each box. The upper and lower quartiles of the data set define the positions of the upper and lower edges of the box, while the width of the box is proportional to the square root of the sample size ($\sqrt{N}$, where N is the number of samples). The highest and lowest spring surface values are represented by short horizontal lines on the graph.

---

[1] Statistical analysis of data from years 1977, 1981 and 1982 has been done to redefine these zones. The write-up and computer programming of these new zones has yet to be completed. Therefore, the same zones used since 1977 have been maintained for this report.

A third cruise was conducted October 3 - 7 (8322044) with the express purpose of verifying the 0.65 conversion factor for specific conductance to total dissolved solids. A summary of the results will be given in this report.

Phosphorus

Figure 3 shows the yearly trend in lakewide spring mean total phosphorus concentrations. Values were area-weighted to compensate for station density throughout the lake. Linear regression analysis described this trend according to the equation

$$y = -0.0010x + 0.0277 \qquad (r = 0.94)$$

i.e., a rate of decrease of 1.0 ug $PL^{-1}yr^{-1}$. If this rate equation can be used as a predictive tool, by 1986 total phosphorus levels in the open waters of Lake Ontario will have achieved the 10.0 ugL^{-1} objective proposed by the Great Lakes Research Advisory Board (July, 1978).

When the t-test was applied to the spring surface total phosphorus raw data for the years 1982 and 1983, a decrease of 8.7% (1.3 $ugPL^{-1}$) was found and the means were significantly different ($p > 0.05$). The test was reapplied to the data using only similar stations for the 2 years and, although only an 1.2 $ugPL^{-1}$ change was noted (8.0%), the decrease was still found to be significant (see Table 2). Note that the actual decrease reported agrees well with the general trend seen in phosphorus levels.

Box plots of spring surface total phosphorus for the period 1970-1983 (shown in Figure 4) demonstrated that 1983 had the lowest median value recorded to date (12.6 $ugPL^{-1}$). However, ice cover, which was experienced over the northeast section of the lake during the spring sampling period in 1982, could have biased the median value for that year. During 1982, ice cover prohibited sampling of all stations in zone 1 during the first spring cruise, and half the stations in zone 1 during the second spring cruise. Table 3 lists the area-weighted surface total phosphorus concentration in each zone, averaged over the two 1983 spring cruises. As zone 1 reported the lowest mean concentration, the data from these stations are undoubtedly included in the minimum-to-low-quartile range of the box plot (i.e. lower 25% of the data) and were instrumental in lowering the 1983 median.

As is demonstrated both by the box plots (Figure 4) and the coefficients of variability (Table 2), even when the full component of stations sampled in 1983 are considered, the variability of the data in 1983 was less than that seen in 1982. This seems to indicate that, at this time, nearshore inputs had localized impact resulting in generally uniform lakewide conditions. The surface plots of total phosphorus for the two Spring cruises (Figures 5, 6) illustrate the nearshore inputs and their zones of impact. On the first cruise (8322001) these included Oshawa (zone 5), Toronto (zone 6), the Welland Canal (zone 9) and Black River Bay (zone 16). On the second cruise (8322004) the major areas of impact were the Welland Canal and Black River Bay, and, to a lesser extent, Oswego (zone 14), Rochester (zone 12) and Hamilton (zone 7). On both cruises, however, these inputs remained fairly localized and did not affect the mid-lake zones 10 and 17.

Linear regression analysis of raw spring surface soluble reactive phosphorus (SRP) data indicated a constant rate of decrease of 0.85 $ugPL^{-1}yr^{-1}$ since 1970 ($r = 0.73$). A comparison of 1982 and 1983 SRP data substantiated this rate change. T-test analysis of spring surface results for the two years, both when applied to all stations and only similar stations sampled, reported a significant ($\alpha = 0.05$) decrease of 19.2% (8.5 $ugPL^{-1}$) and 21.3% (9.5 $ugPL^{-1}$), respectively (Table 2). The 1983 median SRP value (3.4 $ugPL^{-1}$), similar to total phosphorus, was the lowest reported in 14 years. Unlike total phosphorus, however, there was an increase in variability relative to 1982 as illustrated by the coefficients of variability in Table 2.

Surface plots of SRP during the two spring cruises are shown in Figures 7 and 8. Note that the contour lines seem to follow the bathymetry of the lake, there being no remarkable nearshore inputs. On both cruises a nearshore-offshore concentration gradient existed wherein midlake (deep) stations reported higher levels of SRP. Similarly, lowest concentrations were found in the shallow zone 1 region of the lake.

Nitrogen

In 1983, the area-weighted mean surface (NO3+NO2) concentration of 356.0 $ugNL^{-1}$ for the whole lake during spring (isothermal) conditions represented a 0.1 $ugNL^{-1}$ decrease from that of 1982. When a t-test was performed on <u>all</u> the 1m raw data from the 2 years, the means were found to be significantly different at the 95% confidence level (Table 2). It is interesting to note that in the zones along the northern and western shores a (NO3+NO2) decrease relative to 1982 was found, while zones 10, 11, 12, 13, 14 and 17 (central and southern Lake Ontario) showed an increase. Recall that, during the 1982 spring cruises, ice cover prohibited most of the sampling of stations in zone 1. The levels of (NO3+NO2) in this zone during 1983 were among the lowest found throughout the lake (see Appendix 1). Inclusion of the data collected at these stations undoubtedly lowered the

1983 mean concentration. The t-test, therefore, was rerun using only stations sampled during both years. There was then found to be no significant difference between the 2 years ($\alpha = 0.05$).

Although there was no change seen in (NO3+NO2) concentrations from 1982 to 1983, linear regression analysis of the spring surface raw data from 1970 to 1983 indicated a significant rate of increase of 8.3 $ugNL^{-1}yr^{-1}$, or 14000 metric tons/year. Stevens et al. (in press), assuming a similar constant rate of increase of nitrogen, calculated an annual loading of 15000 metric tons per year (5.4 $ugNL^{-1}yr^{-1}$) to Lake Huron. As the volume of Lake Huron: Lake Ontario is approximately 2:1 (Robertson and Jordan 1978), and the rate of change in concentration in Lake Ontario is almost twice that of Lake Huron, the two lakes appear to be responding in a similar manner.

The box plots of spring surface nitrate-plus-nitrite, shown in Figure 9, show an increase in variability for the 1983 results. Whereas, in 1982, 50% of the values were within a 21 ugL^{-1} range, in 1983 the upper and lower quartile differed by 43 ugL^{-1}. As the (median - lower quartile) difference was far greater for 1983 (0.028 compared to 0.012 ugL^{-1}), much of the increased variability can be explained by inclusion of the lower values found at stations in zone 1. When only similar stations were considered, the variability in 1983 decreased considerably. (see Table 2).

A west-east midlake transect was chosen and depth-concentration profiles were made at each station in the transect to investigate any trans-lake (spatial) trend (see Figures 10, 11). On both cruises, levels in the western end and midlake were very similar, while the eastern end of the lake showed lower concentrations.

Total Dissolved Solids

In the 1978 Great Lakes Water Quality Agreement, the objective for total dissolved solids (TDS) in Lake Ontario is 200 mgL^{-1}. However, as TDS analysis is such a time-consuming procedure, specific conductance has instead been used to estimate TDS according to the formula:

$$TDS = SC_{25} \times 0.65 (\pm 0.01) \qquad (1a)$$

where SC_{25} is the specific conductance measured at 25°C. Spring surface total dissolved solids levels, as calculated from equation 1a, have been reported in excess of the IJC objective throughout the lake since 1976 (IJC Annual Report, 1976). Likewise in 1983, with the exception of Black Bay stations 76 and 97 (zone 16) on both cruises, and the stations in zone 9 (Niagara River) during cruise 8322004, the calculated TDS levels were all in excess of 200 mgL^{-1} (18/188 surface measurements were > 200 mgL^{1}).

On the 1983 October cruise (8322044), 1 litre samples were collected from the 1 m depth at 60 stations in Lake Ontario for total dissolved solids analysis. Only 3 of the 60 reported TDS values were above 200 mgL^{-1} (see Table 4). In contrast, when the conductivity values from this cruise were converted to TDS using equation 1a, 44 of the 60 stations showed TDS levels at or above the objective. Table 4 gives, for each station, the TDS/SC_{25} ratio. It appears, from this set of data, that a more exact conversion factor would be 0.58, ie.

$$TDS = SC_{25} \times 0.58 (\pm 0.03) \qquad (1b)$$

Applying equation 1b to the spring conductivity values, only 41/94 stations on cruise 8322001 and 5/94 stations on cruise 8322004 exceeded the 200 mgL^{-1} objective. Perhaps the continually-reported objective noncompliance has been reflectant of the conversion factor rather than the state of the lake. It is recommended that this comparative study be repeated during the 1984 spring cruises.

Violations of Objectives in 1978 Great Lakes
Water Quality Agreement - 1983

Problem Area	Object Violated	Remarks
1. Whole lake except - Stns 76, 77 (both cruises) - Stns in zone 9 during cruise 8322004	Total dissolved solids >200 mg/litre	Long term problem. Values calculated from specific conductance by conversion factor of 0.65
2. Specific to Station 81. Dates and values listed	Dissolved oxygen <6.0 mg/litre	Long term problem.

Date	Depth	Value
08/04	25.0m	5.94 mg/l
	33.0	5.36
08/09	25.0	5.47
	33.0	5.14
09/20	33.0	5.41
09/27	29.0	5.75
	34.0	5.39

References

McGill, R.J., T.W. Tukey and W.A. Larsen (1978) Variations of box plots. Am. Stat. 32: 12-16.

Neilson, M.A., R.J.J. Stevens and J. Hodson (1984) Documentation of the averaging lake data by regions (ALDAR) program. Inland Waters Directorate. Technical Bulletin No. 130 Ottawa, Canada. 87p.

Robertson, D.G. and D.E. Jordan (1978) Digital Bathymetry of Lakes Ontario, Erie, Huron, Superior and Georgian Bay. CCIW unpublished manuscript.

Stevens, R.J.J., M.A. Neilson and N.D. Warry. Water quality of the Lake Huron - Georgian Bay system. In press.

TABLE 1. PARAMETERS MEASURED ON 1983 LAKE ONTARIO CRUISES

	03/14 - 03/18	04/05 - 04/09	10/03 - 10/07
No. of Stations Sampled	94	94	60
Depth	X	X	X
Secchi Disk	X	X	X
Colour	X	X	X
Temperature	X	X	X
% Transmission	X	X	X
Specific Conductance	X	X	X
pH	X	X	X
Alkalinity (f)	X	X	X
Particulate Organic Carbon (int)	X	X	
Dissolved Organic Carbon	X	X	
Dissolved Oxygen	X	X	
% Oxygen Saturation	X	X	
Total Phosphorus	X	X	
Soluble Reactive Phosphorus	X	X	
Total Filtered Phosphorus	X	X	
Total Particulate Nitrogen (int)	X	X	
Ammonia (f)	X	X	
Nitrate + Nitrite (f)	X	X	
Total Nitrogen (f)	X	X	
Sulphate (f)	X	X	X
Chloride (f)	X	X	X
Soluble Reactive Silica	X	X	X
Calcium (f)	X	X	X
Magnesium (f)	X	X	X
Potassium (f)	X	X	X
Sodium (f)	X	X	X
Total Dissolved Solids			X
Chlorophyll a	X	X	X

f = filtered samples
int = 0-20M integrated sample

Table 2: T-test results for 1982 versus 1983 spring surface nutrients TP, SRP, NO3+NO2. (α = 0.05)

Parameter	Mean (mg/l)	Standard Deviation (mg/l)	Coef. of Variation (%)	T-Value
82 TP	0.0146	0.0033	22.7	
83	0.0133	0.0024	18.0	3.46*
82(a)	0.0146	0.0033	22.7	
83(a)	0.0134	0.0023	16.8	2.99*
82 SRP	0.0047	0.0021	45.6	
83	0.0038	0.0025	65.4	3.07*
82(a)	0.0047	0.0021	45.6	
83(a)	0.0037	0.0025	67.8	2.97*
82 NO3+NO2	0.3604	0.0259	7.2	
83	0.3520	0.0298	8.5	2.51*
82(a)	0.3604	0.0259	7.2	
83(a)	0.3537	0.0281	8.0	1.80

* significantly different.

(a) only similar stations included in t-test.

Table 3: Area-weighted surface total and soluble reactive phosphorus concentrations for each zone, averaged over the two 1983 spring cruises, and number of stations sampled in each zone (n). All values are in $mgPL^{-1}$.

Zone	n	Total Phosphorus	Soluble Reactive Phosphorus
1	8	0.0114	0.0009
2	1	0.0121	0.0018
3	2	0.0130	0.0024
4	4	0.0124	0.0023
5	4	0.0133	0.0036
6	5	0.0140	0.0037
7	5	0.0150	0.0034
9	9	0.0163	0.0025
10	12	0.0130	0.0064
11	4	0.0146	0.0019
12	3	0.0140	0.0035
13	2	0.0124	0.0044
14	4	0.0125	0.0038
15	4	0.0119	0.0020
16	3	0.0162	0.0021
17	24	0.0125	0.0056
Whole Lake	94	0.0128	0.0045

Table 4: Calculating total dissolved solids (TDS) content from specific conductance (SC_{25}) on cruise 8322044.

Station	Actual TDS (mg/L)	SC_{25} (usiemens)	$\frac{TDS}{SC_{25}}$	$SC_{25} \times 0.65$
001	193.	331.	0.58	215.
003	184.	321.	0.57	209.
014	184.	315.	0.58	205.
013	190.	321.	0.59	209.
015	184.	322.	0.57	209.
096	178.	304.	0.59	198.
016	188.	317.	0.59	206.
017	172.	314.	0.55	204.
018	178.	317.	0.56	206.
019	172.	310.	0.55	202.
020	193.	293.	0.66	190.
086	182.	307.	0.59	200.
021	169.	309.	0.55	201.
022	148.	287.	0.52	187.
093	169.	287.	0.59	187.
023	204.	310.	0.66	202.
024	201.	316.	0.64	205.
025	198.	313.	0.63	203.
026	184.	371.	0.58	206.
033	194.	316.	0.61	205.
034	180.	307.	0.59	200.
035	179.	295.	0.61	192.
008	202.	321.	0.63	209.
012	177.	314.	0.56	204.
041	184.	312.	0.59	203.
040	188.	310.	0.61	202.
053	179.	306.	0.58	199.
057	163.	308.	0.53	200.

Table 4 (continued)

Station	Actual TDS (mg/L)	SC_{25} (usiemens)	$\frac{TDS}{SC_{25}}$	$SC_{25} \times 0.65$
087	185.	308.	0.60	200.
058	180.	309.	0.58	201.
059	176.	307.	0.57	200.
060	172.	307.	0.56	200.
064	184.	280.	0.66	182.
069	185.	309.	0.60	201.
070	175.	303.	0.58	197.
071	196.	355.	0.55	231.
072	174.	307.	0.57	200.
088	174.	307.	0.57	200.
073	179.	306.	0.58	199.
089	187.	306.	0.61	199.
074	178.	314.	0.57	204.
075	177.	304.	0.58	198.
097	162.	260.	0.62	169.
076	174.	298.	0.58	194.
098	174.	304.	0.57	198.
077	156.	306.	0.51	199.
078	180.	302.	0.60	196.
079	170.	309.	0.55	201.
081	179.	310.	0.58	202.
090	175.	313.	0.56	203.
083	176.	312.	0.56	203.
062	170.	311.	0.55	202.
061	170.	311.	0.55	202.
046	170.	310.	0.55	202.
091	183.	314.	0.58	204.
031	186.	322.	0.58	209.
028	179.	314.	0.57	204.
011	186.	322.	0.58	209.
006	188.	322.	0.58	209.
002	192.	324.	0.59	211.
Mean value			0.58 ± 0.03	

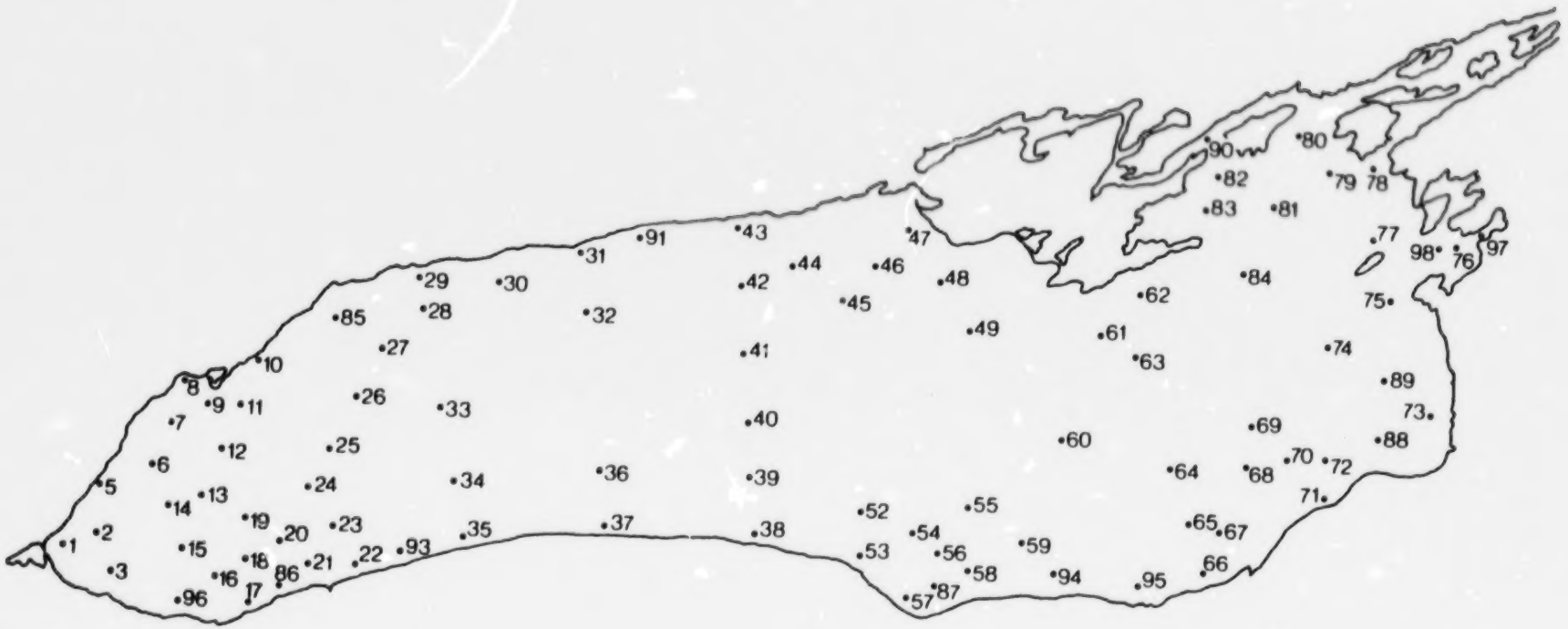

Figure 1. Lake Ontario Station Locations

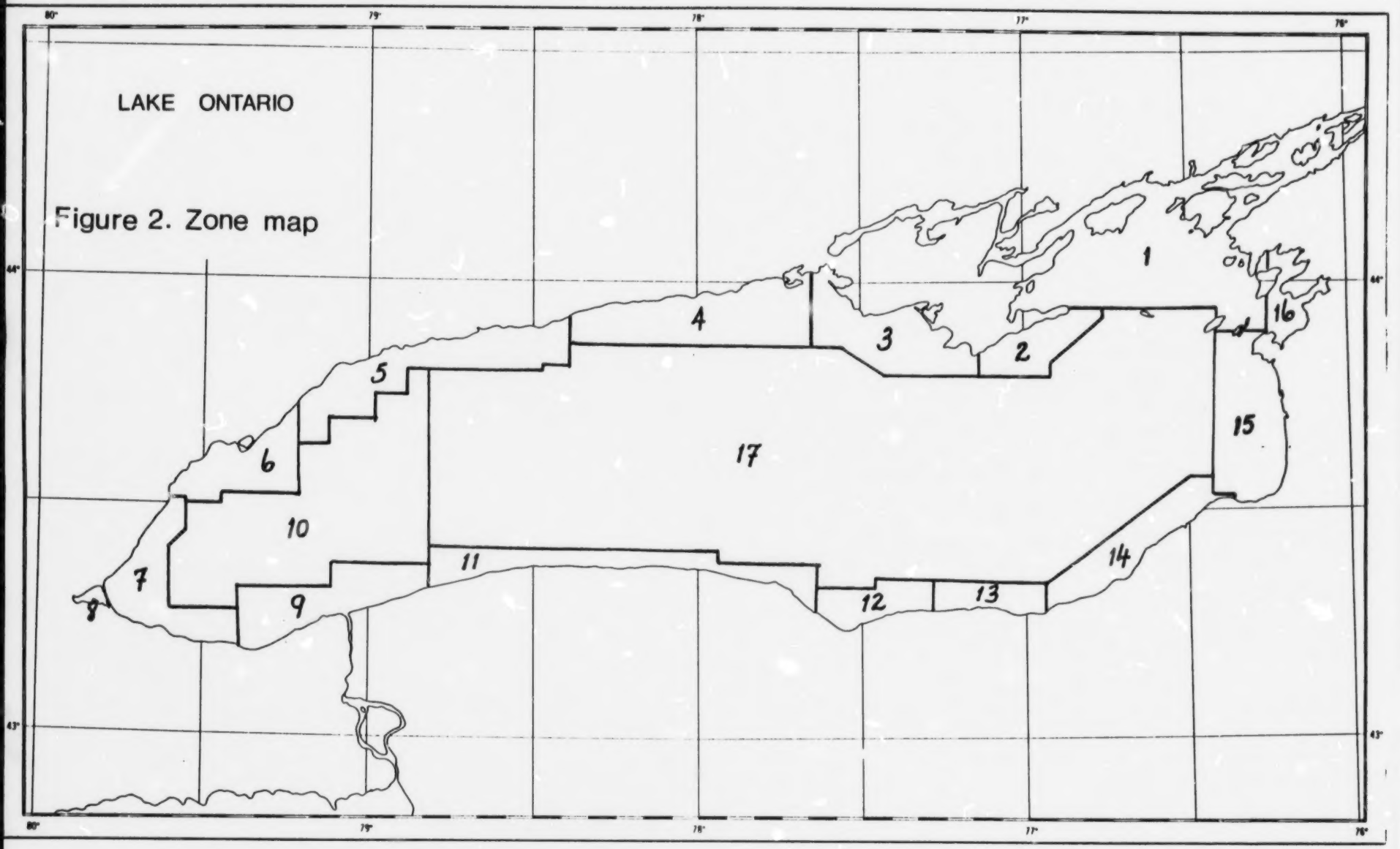

Figure 2. Zone map

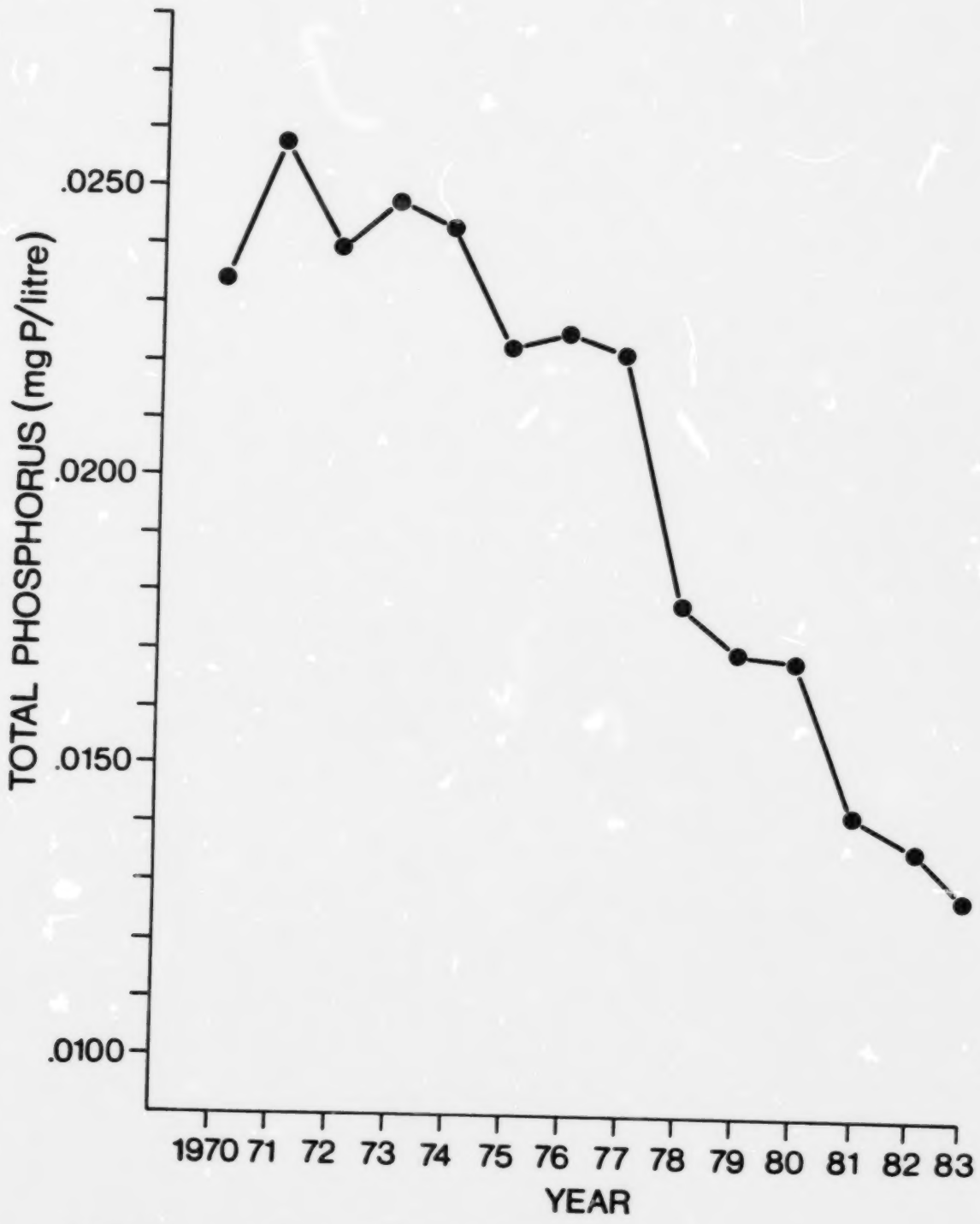

FIGURE 3. AREA-WEIGHTED MEAN WHOLE LAKE SPRING TOTAL PHOSPHORUS CONCENTRATIONS

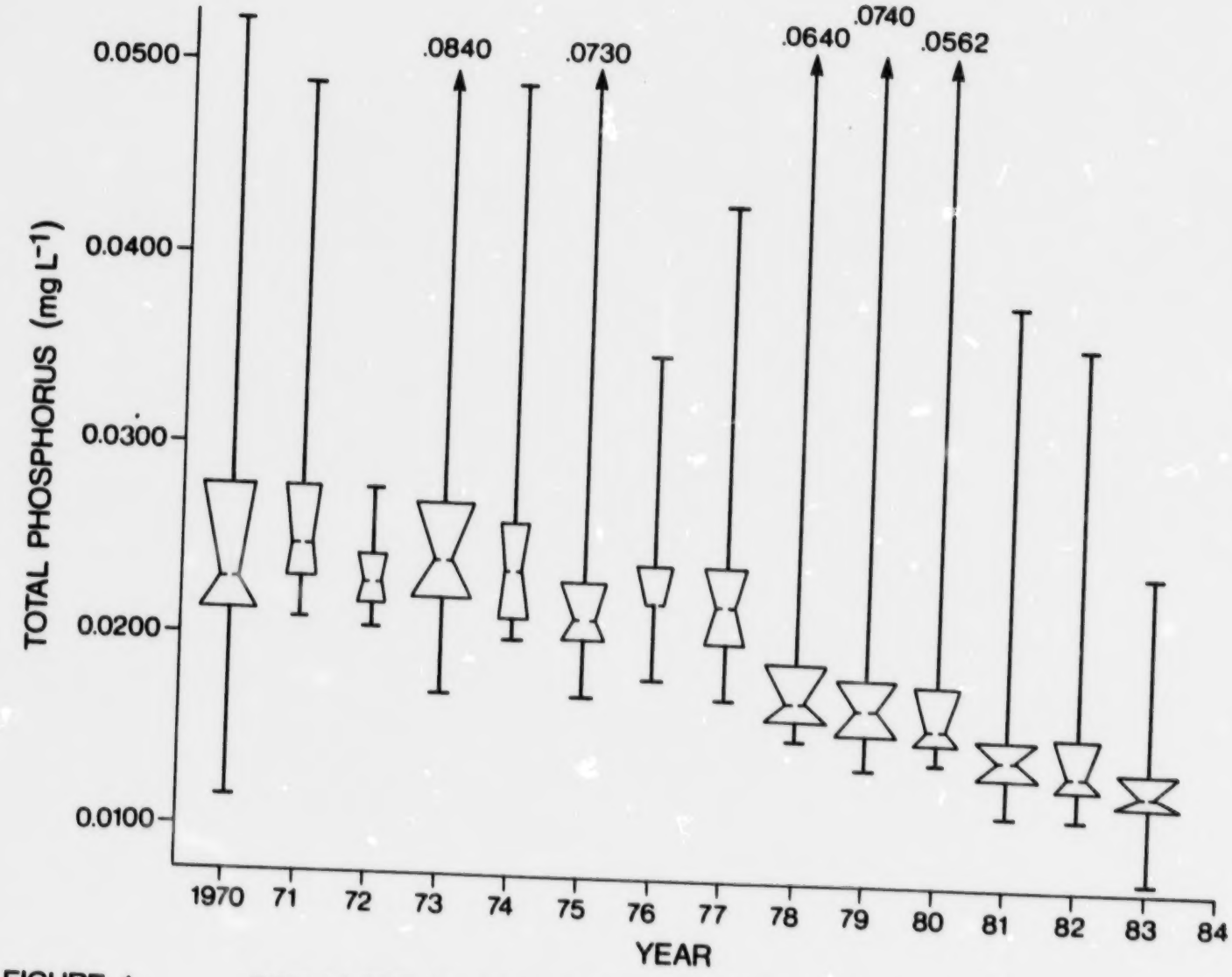

FIGURE 4 BOX PLOTS OF SPRING SURFACE (1m) TOTAL PHOSPHORUS

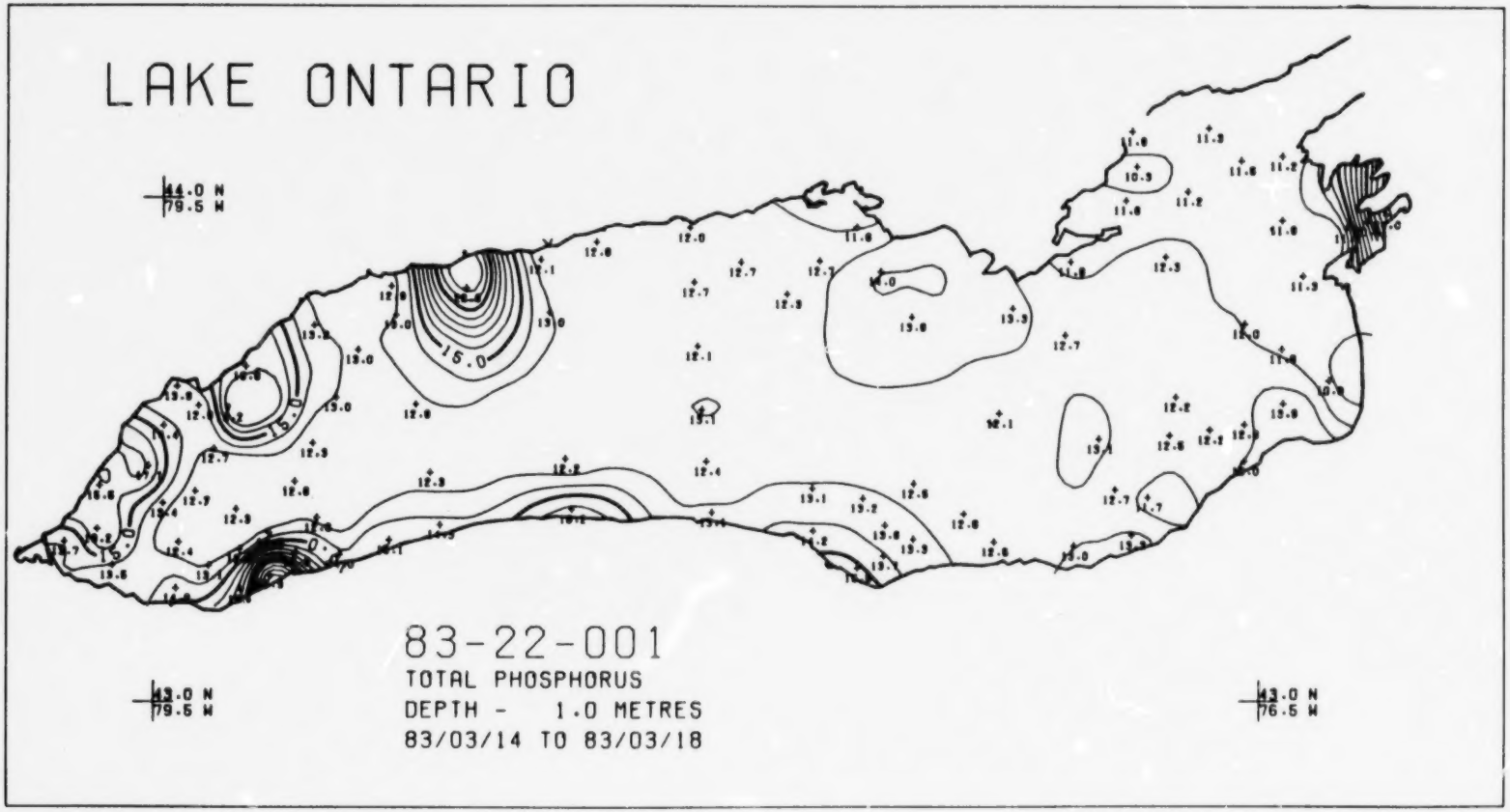

FIGURE 5 SURFACE PLOT OF TOTAL PHOSPHORUS - CRUISE 8322001
CONTOURS ARE IN µg/L

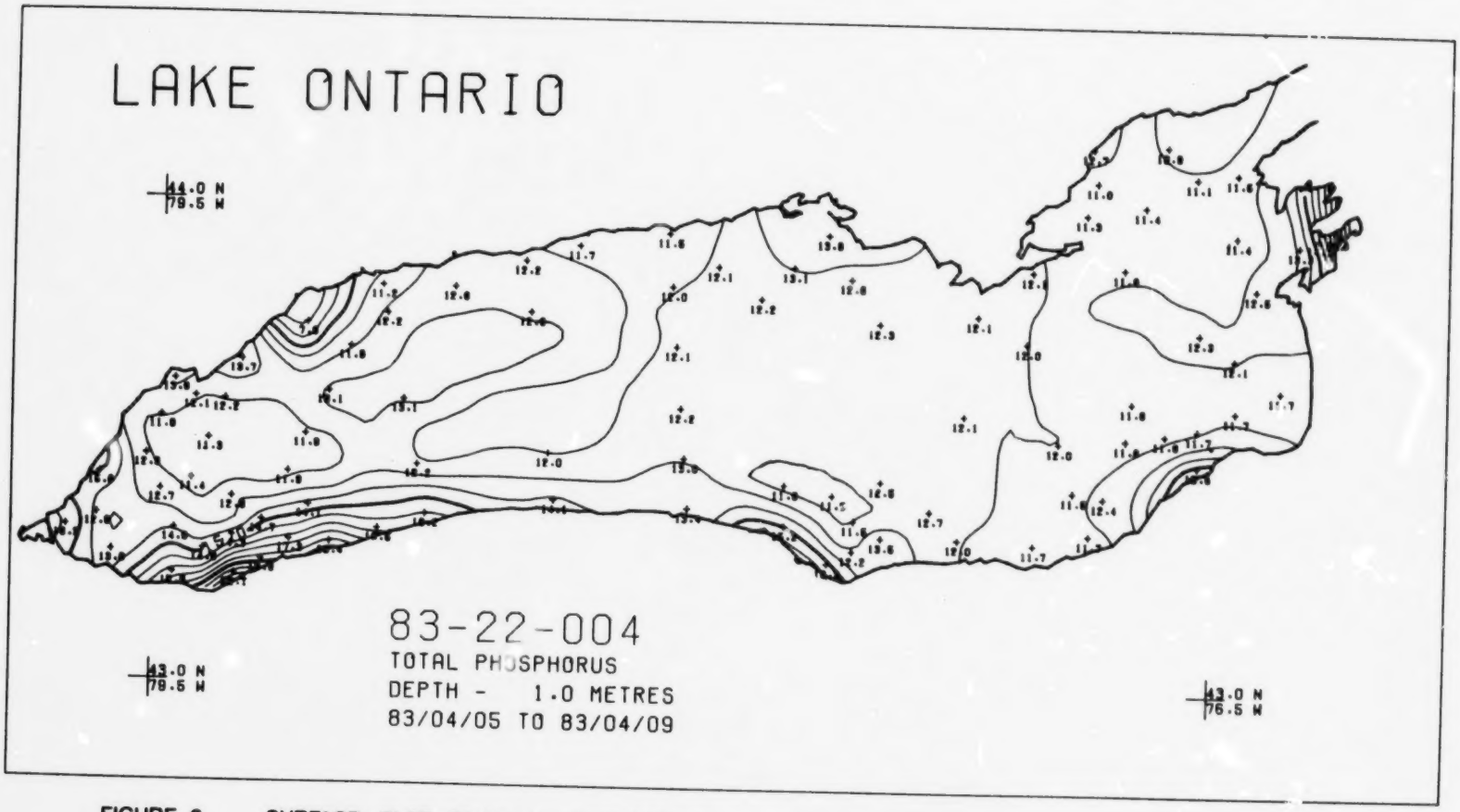

FIGURE 6 SURFACE PLOT OF TOTAL PHOSPHORUS - CRUISE 8322004
CONTOURS ARE IN µg/L

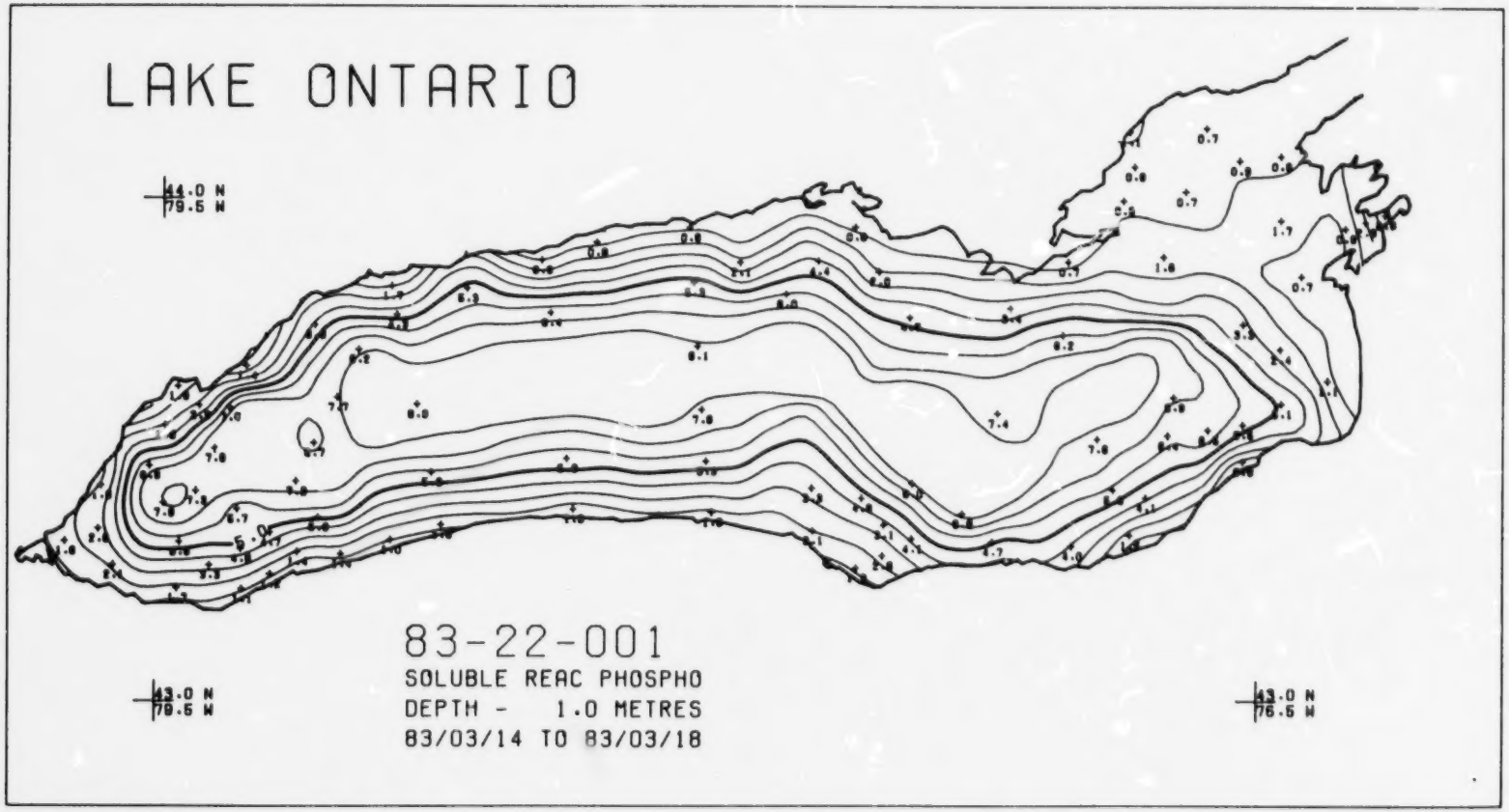

FIGURE 7 SURFACE PLOT OF SOLUBLE REACTIVE PHOSPHORUS - CRUISE 8322001
CONTOURS ARE IN µg/L

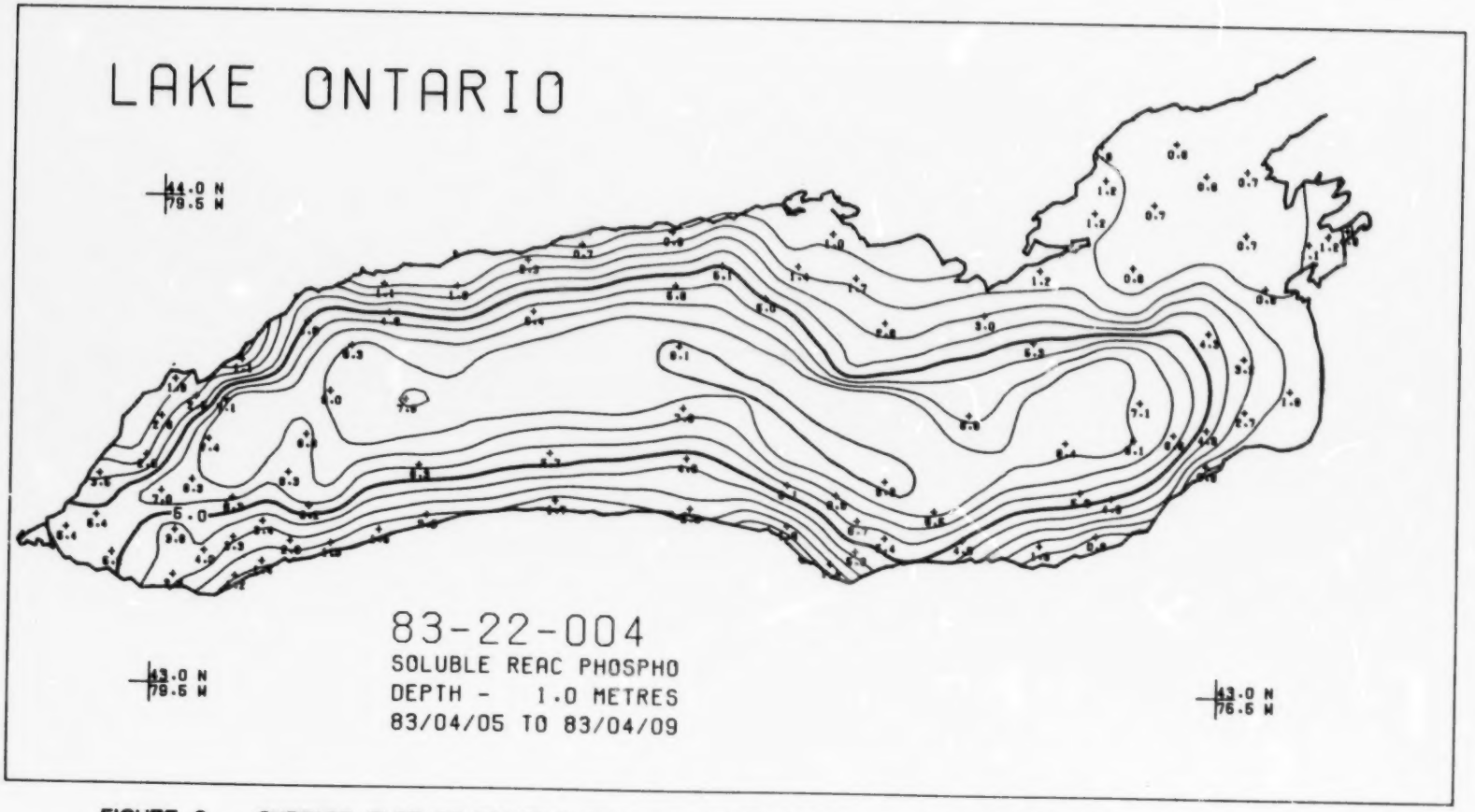

FIGURE 8 SURFACE PLOT OF SOLUBLE REACTIVE PHOSPHORUS - CRUISE 8322004
CONTOURS ARE IN µg/L

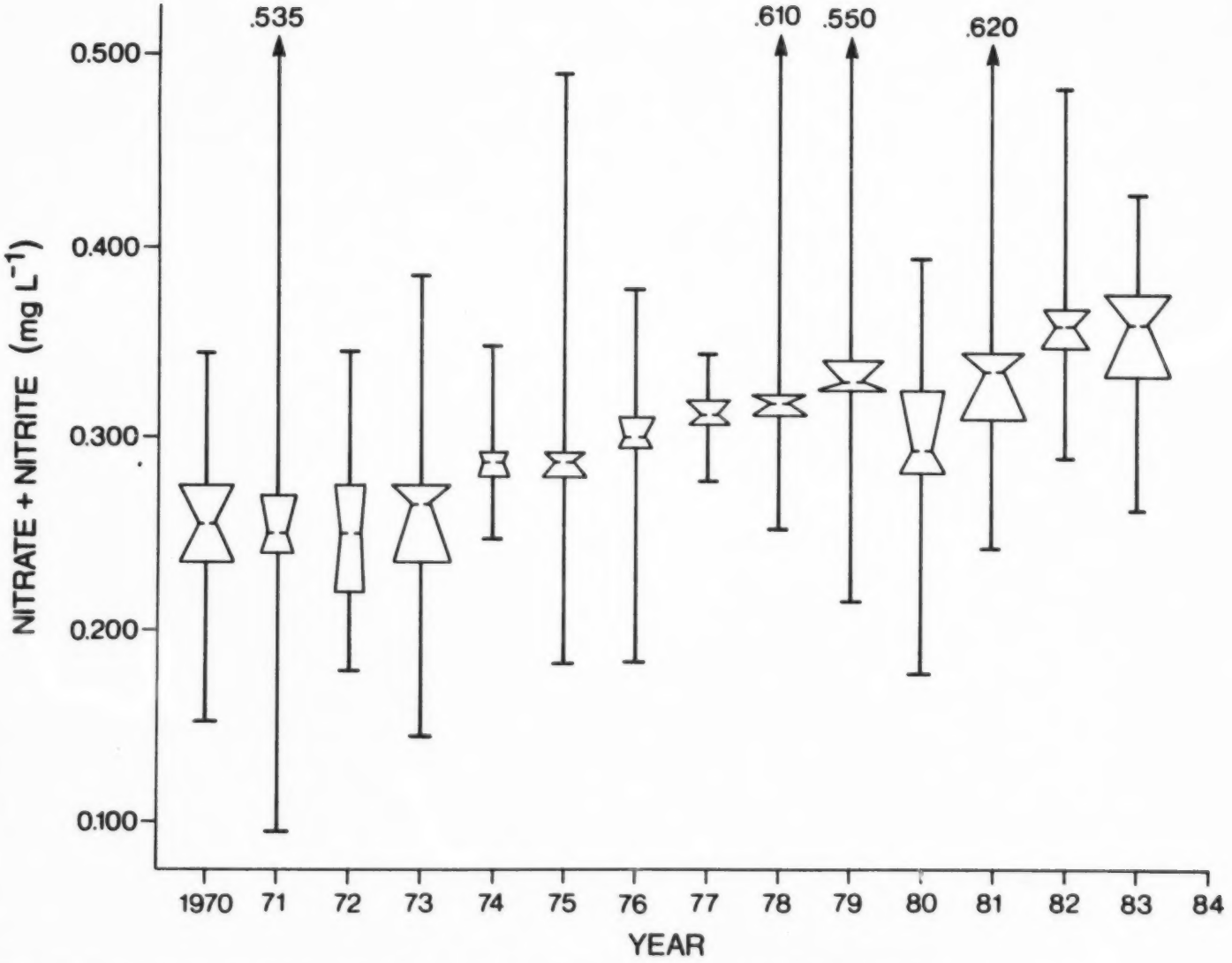

FIGURE 9 - BOX PLOTS OF SPRING SURFACE (1m) FILTERED NITRATE + NITRITE

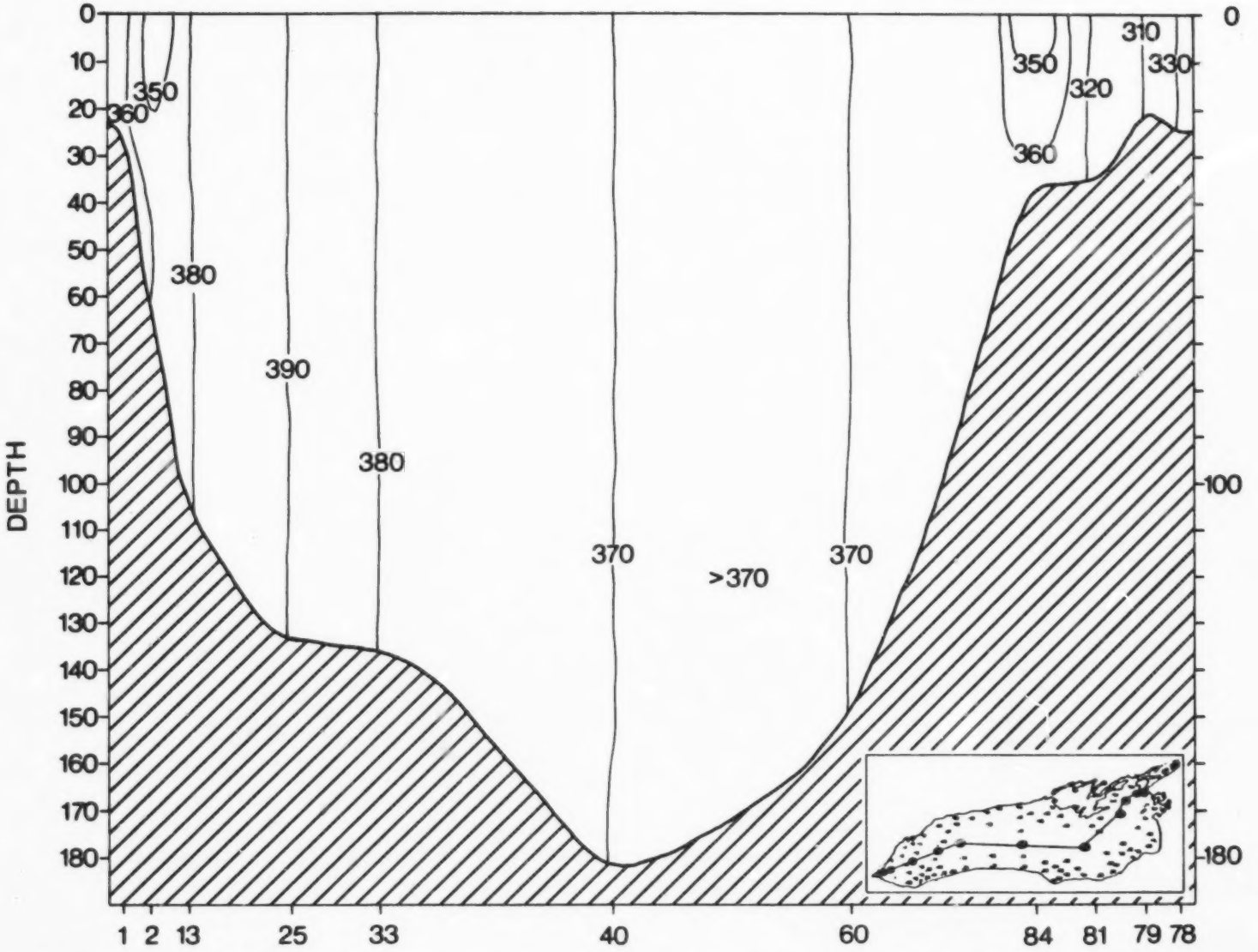

FIGURE 10 (NO_3 + NO_2) CONCENTRATIONS ALONG WEST-EAST MIDLAKE TRANSECT DURING CRUISE 822001 (mg/L)

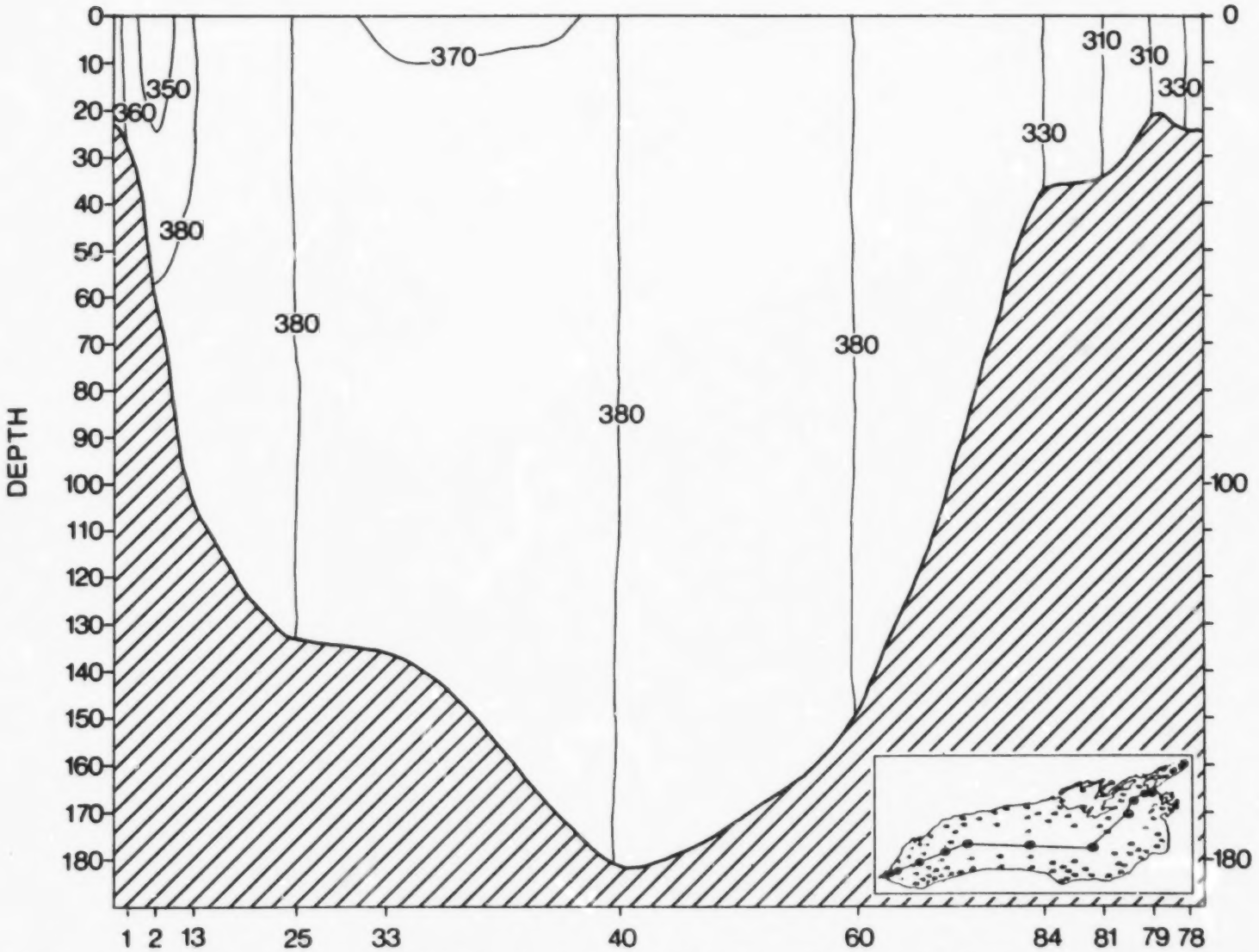

FIGURE 11 (NO_3 + NO_2) CONCENTRATIONS ALONG WEST-EAST MIDLAKE TRANSECT DURING CRUISE 8322004 (mg/L)

Appendix I

Area-weighted mean spring surface concentrations
for each of the zones and the entire lake.

LAKE ONTARIO
TOTAL PHOSPHORUS
mg P/litre

1M DEPTH
SPRING CRUISES

ZONE	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1		0.0245	0.0222	0.0257	0.0243	0.0220	0.0207	0.0229	0.0226	0.0166	0.0168	0.0147	0.0137	-a	0.011
2		0.0248	0.0219	0.0254	0.0237	0.0220	0.0194	0.0229	0.0207	0.0169	0.0166	0.0152	0.0132	0.0140	0.012
3		0.0219	0.0247	0.0245	0.0252	0.0218	0.0201	0.0222	0.0208	0.0174	0.0162	0.0154	0.0137	0.0124	0.013
4		0.0238	0.0256	0.0248	0.0247	0.0218	0.0216	0.0211	0.0214	0.0176	0.0162	0.0159	0.0145	0.0135	0.012
5		0.0264	0.0272	0.0273	0.0250	0.0237	0.0217	0.0227	0.0213	0.0190	0.0195	0.0183	0.0158	0.0136	0.013
6		0.0318	0.0378	0.0250	0.0293	0.0300	0.0230	0.0231	0.0231	0.0195	0.0228	0.0200	0.0167	0.0167	0.014
7		0.0275	0.0299	0.0229	0.0254	0.0221	0.0215	0.0229	0.0226	0.0194	0.0180	0.0174	0.0147	0.0141	0.015
8		-	-	-	-	-	-	-	-	-	-	-	-	-	-
9		0.0273	0.0337	0.0268	0.0376	0.0277	0.0324	0.0241	0.0246	0.0212	0.0208	0.0210	0.0155	0.0154	0.016
10		0.0223	0.0250	0.0238	0.0247	0.0244	0.0213	0.0253	0.0214	0.0171	0.0159	0.0158	0.0144	0.0131	0.013
11		0.0230	0.0290	0.0241	0.0321	0.0355	0.0292	0.0231	0.0216	0.0225	0.0200	0.0224	0.0156	0.0160	0.014
12		0.0257	0.0254	0.0248	0.0278	0.0228	0.0258	0.0299	0.0214	0.0254	0.0185	0.0172	0.0155	0.0154	0.014
13		0.0239	0.0294	0.0234	0.0249	0.0222	0.0240	0.0210	0.0217	0.0177	0.0179	0.0169	0.0148	0.0141	0.012
14		0.0239	0.0299	0.0226	0.0250	0.0218	0.0249	0.0241	0.0243	0.0180	0.0187	0.0171	0.0155	0.0149	0.012
15		0.0248	0.0255	0.0247	0.0246	0.0218	0.0230	0.0213	0.0220	0.0176	0.0193	0.0163	0.0145	0.0146	0.011
16		0.0247	0.0250	0.0254	0.0247	0.0220	0.0248	0.0238	0.0230	0.0172	0.0223	0.0181	0.0155	-a	0.016
17		0.0223	0.0248	0.0229	0.0235	0.0246	0.0215	0.0219	0.0225	0.0174	0.0160	0.0169	0.0138	0.0135	0.012
WHOLE LAKE		0.0234	0.0257	0.0239	0.0248	0.0243	0.0222	0.0225	0.0222	0.0178	0.0170	0.0169	0.0142	0.0137	0.012

-a Ice cover prohibited sampling in these zones.

LAKE ONTARIO
FILTERED NITRATE + NITRITE
mg N/litre

1 M DEPTH
SPRING CRUISES

ZONE	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1	0.1892	0.2256	0.2198	0.1731	0.2274	0.2820	0.2031	0.2456	0.3186	0.2953	0.2734	0.2401	0.2756	-a	0.3146
2	0.2146	0.2190	0.2452	0.1786	0.2325	0.2820	0.2200	0.2918	0.3166	0.2939	0.2942	0.2621	0.2645	0.3470	0.3176
3	0.1865	0.2235	0.2252	0.2031	0.2489	0.2774	0.2540	0.2574	0.3058	0.3085	0.3192	0.2797	0.2999	0.3517	0.3404
4	0.2127	0.2338	0.2282	0.2599	0.2657	0.2549	0.2727	0.2174	0.3015	0.3110	0.3267	0.2729	0.3174	0.3342	0.3225
5	0.2457	0.2662	0.2585	0.2359	0.2580	0.2806	0.2887	0.2858	0.3167	0.3227	0.3391	0.3073	0.3510	0.3665	0.3329
6	0.2471	0.2793	0.2682	0.2554	0.3151	0.3040	0.2937	0.3078	0.3265	0.3234	0.3500	0.3430	0.3519	0.3835	0.3447
7	0.2490	0.2965	0.2607	0.2405	0.2634	0.2910	0.2879	0.3084	0.3180	0.3349	0.3431	0.3340	0.3416	0.3686	0.3590
8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	0.2118	0.2425	0.2463	0.1979	0.2619	0.3149	0.2892	0.3007	0.3065	0.3221	0.3092	0.3100	0.3280	0.3621	0.3329
0	0.2419	0.2583	0.2506	0.2386	0.2605	0.2966	0.2866	0.3038	0.3076	0.3176	0.3327	0.3320	0.3424	0.3580	0.3688
1	0.2400	0.2421	0.2548	0.1950	0.2494	0.2891	0.2804	0.3093	0.3028	0.2997	0.3303	0.2690	0.3100	0.3452	0.3512
2	0.2474	0.2486	0.2450	0.1850	0.2561	0.2889	0.2899	0.2960	0.3114	0.3583	0.3506	0.3063	0.3201	0.3654	0.3716
3	0.2355	0.2319	0.2416	0.2703	0.2473	0.2934	0.2890	0.2995	0.3181	0.3152	0.3292	0.3153	0.3265	0.3568	0.3717
4	0.2340	0.2528	0.2934	0.2550	0.2451	0.2928	0.3044	0.2964	0.3165	0.3137	0.3393	0.3151	0.3276	0.3607	0.3645
5	0.2422	0.2422	0.2573	0.1713	0.2406	0.2884	0.2571	0.3290	0.3180	0.3190	0.3397	0.3039	0.3220	0.3542	0.3455
6	0.2032	0.2267	0.2363	0.1725	0.2344	0.2820	0.4811	0.3197	0.3180	0.3180	0.3751	0.3240	0.3262	-a	0.3484
7	0.2391	0.2396	0.2601	0.2255	0.2453	0.2842	0.2797	0.2996	0.3159	0.3150	0.3322	0.3161	0.3298	0.3578	0.3662
HOLE AKE	0.2331	0.2438	0.2539	0.2217	0.2494	0.2860	0.2772	0.2937	0.3141	0.3150	0.3289	0.3083	0.3259	0.3561	0.3560

-a Ice cover prohibited sampling in these zones.

LAKE ONTARIO
SPECIFIC CONDUCTANCE
umhos/cm
1M DEPTH
SPRING CRUISES

ZONE	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982*	19
1	339.8	340.2	360.7	336.9	339.7	336.0	330.1	334.9	335.2	334.3	334.2	332.0	325.9	-a	334.
2	333.0	241.4	368.5	339.6	338.8	336.0	336.9	334.7	336.1	334.4	337.4	338.9	332.1	348.3	345.
3	317.1	339.7	371.7	338.5	335.3	335.1	327.7	337.4	337.5	337.1	336.8	356.8	333.3	345.5	337.
4	326.3	340.3	371.7	340.0	338.7	333.6	331.7	336.6	339.4	336.8	337.7	342.8	333.7	344.3	343.
5	346.4	340.2	373.5	338.9	341.1	326.9	338.1	339.8	339.3	338.7	337.7	349.9	318.7	345.6	336.
6	330.9	342.6	372.3	342.4	343.7	335.0	331.9	335.6	341.5	339.3	340.8	352.9	318.1	348.2	338.
7	330.9	343.7	357.6	338.0	342.1	336.0	328.2	338.0	337.4	339.1	334.3	348.3	335.1	348.7	330.
8	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
9	335.5	344.1	363.6	333.0	335.7	325.7	326.2	345.3	328.3	329.4	321.1	325.5	330.6	349.7	303.
10	337.3	339.4	364.8	335.9	341.5	331.9	334.5	341.0	336.2	334.5	334.7	342.6	328.6	346.2	323.
11	342.2	342.8	365.5	331.8	338.1	318.2	329.0	347.3	330.4	328.1	326.9	311.1	320.6	339.5	316.
12	316.9	346.5	371.0	333.5	341.2	332.1	334.4	334.1	337.8	336.5	330.7	327.7	327.6	346.2	325.
13	307.0	345.4	358.7	336.1	339.4	328.1	334.1	341.3	337.3	332.6	325.9	331.6	330.4	343.2	332.
14	337.0	345.1	361.7	337.9	342.9	327.2	332.8	343.6	336.5	330.7	337.2	331.9	331.1	346.2	333.
15	347.1	341.5	365.5	344.6	339.7	336.8	327.5	330.4	335.8	335.8	331.9	330.8	326.8	345.4	347.
16	335.6	338.8	361.3	341.8	325.8	336.0	195.7	161.9	333.0	330.6	276.9	279.3	329.2	-a	272.
17	325.8	340.7	363.6	337.8	339.3	334.8	332.5	342.6	337.4	334.8	335.0	337.3	331.3	344.8	331.
WHOLE LAKE	330.5	341.0	364.7	337.8	339.5	333.3	331.0	338.7	336.8	334.8	333.8	337.1	329.6	345.5	330.

* Original data appeared suspect. Therefore, conductance (S.C.) was calculated according to the equation

$$S.C. = 2.60(Ca)+3.82(Mg)+2.13(Na)+1.84(K)+2.14(Cl)+0.864(Alk)+1.54(SO_4)$$

-a Ice cover prohibited sampling in these zones.

LAKE ONTARIO
FILTERED CHLORIDE
mg Cl/litre

1M DEPTH
SPRING CRUISES

ZONE	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
1			28.40	29.14	28.01	29.40	28.37	26.61	27.70	27.52	26.95	26.64	25.90	-a	25.62
2			28.48	29.01	28.19	29.40	28.65	27.25	28.10	27.79	27.71	27.12	27.02	27.01	25.77
3			28.78	28.81	28.04	29.27	28.65	27.35	27.71	28.09	27.77	27.56	27.26	27.05	25.77
4			29.19	28.50	27.96	28.80	29.05	27.33	27.92	28.10	27.77	27.16	27.49	26.69	25.79
5			29.28	29.42	28.38	28.76	29.18	27.56	28.25	28.28	28.04	27.39	27.41	27.12	26.11
6			30.41	29.77	28.25	29.10	29.66	28.54	28.75	28.15	28.47	27.73	27.72	27.70	26.68
7			29.16	28.09	28.58	28.65	29.19	29.05	28.05	28.24	28.04	27.76	27.22	27.43	26.55
8			-	-	-	-	-	-	-	-	-	-	-	-	-
9			28.06	27.82	27.32	27.06	27.17	26.23	26.06	26.43	25.95	25.19	26.54	26.77	22.64
10			28.80	28.60	27.89	28.31	29.01	27.31	27.76	27.76	27.71	27.53	27.02	26.48	26.04
11			28.18	27.53	27.24	28.25	27.16	24.89	26.47	25.24	26.27	22.70	24.23	23.89	24.39
12			28.50	28.16	27.57	28.90	28.41	25.67	27.74	27.86	27.59	25.44	25.03	25.82	25.92
13			28.24	28.37	27.93	28.68	28.88	26.69	27.98	27.43	26.65	26.25	25.94	25.95	25.89
14			28.41	28.53	28.00	28.57	28.71	26.62	28.05	27.63	28.07	26.64	26.23	26.81	26.92
15			28.78	29.73	27.89	28.86	28.56	26.24	27.92	28.09	27.72	26.93	26.10	27.08	26.48
16			28.62	29.80	27.93	29.40	13.72	25.41	27.80	27.68	22.71	21.55	25.43	-a	19.88
17			28.93	28.93	27.97	28.84	28.64	26.78	28.03	27.88	27.67	27.10	27.03	26.37	25.88
WHOLE LAKE			28.85	28.84	27.96	28.76	28.49	26.88	27.88	27.77	27.54	26.89	26.82	26.52	25.77

a Ice cover prohibited sampling in these zones.